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Amendments to the Drawings

The attached sheets of drawings include changes to Figs. 1, 2 and 3. These sheets replace the original sheets of Figs. 1, 2 and 3. In Fig. 1, the label "Prior Art" has been added; in Figs. 2 and 3, the reference character 28, which previously designated sunlight, has been changed to reference character 14.

Attachments: Replacement Sheets

 Annotated Sheets Showing Changes

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Remarks/Arguments

Applicant respectfully requests favorable reconsideration of the subject application, particularly in view of the above amendment and the following remarks. There is no additional fee for the above amendment as the number of independent claims and the total number of claims remain unchanged.

Claims 1-26, all of which have been rejected, are currently pending in the subject application.

Applicant has amended Fig. 1 of the subject application by labeling the figure as "Prior Art". Applicant has amended Figs. 2 and 3 by changing reference character 28, which originally designated sunlight, to reference character 14, which designates sunlight in Fig. 1 of the drawings.

Applicant has amended the specification by changing the designation of sunlight as reference character 28, as necessary, to reference character 14. In addition, Applicant has amended the specification to identify the photoelectrode assembly shown in Fig. 4 as reference character 30. Applicant has further amended the specification to provide appropriate recognition of the proprietary nature of the trademarks NAFION® and PLEXIGLAS® therein.

Applicant has amended Claims 7 and 20 by deleting the trademark NAFION® and inserting in its place the corresponding generic terminology therefor.

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Similarly, Applicant has amended Claims 12 and 25 by deleting the trademark PLEXIGLAS® and inserting in its place the corresponding generic terminology therefor.

Claim 23 has been amended to correct an obvious typographical error.

Finally, Applicant has amended Claim 14 of the subject application to include the further limitation of the presence of a space between at least one of the semiconductor photoanode and the semiconductor photocathode and the light transmissive wall of the cell enclosure. This amendment is fully supported, for example, by Figs. 2 and 3 of the subject application as well as the description of the invention beginning at Page 4, line 9 of the specification of the subject application. Accordingly, Applicant respectfully urges that this amendment is fully supported by the application as originally filed and, thus, incorporates no new subject matter into the application.

The drawings have been objected to as failing to comply with 37 CFR 1.84(p)(4) because the reference character "28" has been used to designate two elements, sunlight and electrolyte, in Figs. 2 and 3. In response to this objection, Applicant has amended the drawings to utilize reference character "14" to designate sunlight, which is consistent with the designation of sunlight shown in Fig. 1. To the

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extent that the specification also uses reference character 28 to designate sunlight, the specification has been amended to designate sunlight as reference character 14.

Fig. 1 has been objected to for failing to provide a legend to indicate that it shows only that which is old subject matter. In response, Applicant has added the label "Prior Art" to Fig. 1.

The drawings have also been objected to as failing to comply with 37 CFR 1.84(p)(5) because Fig. 4 of the drawings includes reference character 30, which is not described in the specification. In response thereto, Applicant has amended the specification to include a description of reference character 30. Applicant respectfully urges that the amendments to the drawings and specification as set forth herein above overcome the objections to the drawings.

Claims 7 and 20 have been objected to for failing to provide adequate acknowledgment of the proprietary nature of the trademark NAFION®. In response thereto, Applicant has deleted the trademark from the claims and inserted the appropriate generic description associated with the trademark.

Claims 12 and 25 have been objected to for failing to provide adequate acknowledgment of the proprietary nature of the trademark PLEXGLAS®. In response thereto, Applicant has deleted the trademark from the claims and inserted the appropriate generic description associated with the trademark. Applicant respectfully

urges that these amendments to Claims 7, 12, 20 and 25 overcome the objections to the claims.

The invention claimed by Applicant is a photoelectrochemical cell comprising at least one semiconductor photoelectrode, a second electrode and an electrolytic solution disposed there between, and a housing enclosing the photoelectrochemical cell, which housing comprises at least one light transmissive wall. The at least one *semiconductor photoelectrode* comprises a *proton exchange membrane* having an electrolyte facing surface in contact with the electrolytic solution and a light transmissive wall facing surface. Disposed on the light transmissive wall facing surface of the at least one semiconductor photoelectrode is a photo electro-catalyst. A *critical feature* of the invention claimed by Applicant is the *disposition of the at least one semiconductor photoelectrode at a distance from the at least one light transmissive wall*, thereby forming a space between the at least one semiconductor photoelectrode and the at least one light transmissive wall, in which space there is substantially no electrolytic solution present. As discussed beginning at Page 7, line 4 of the subject application, in conventional photoelectrolysis cells, there is a layer of electrolyte between the transparent enclosure and the photoelectrode, which results in the loss of a substantial amount of solar energy as the sunlight passes through the liquid layer. By providing a space between the light

transmissive wall of the enclosure and the at least one semiconductor photoelectrode in which there is substantially no electrolyte present, this issue is addressed. That is, the sunlight is transmitted directly onto the photoelectrode without any significant transmission-interfering restriction between the light transmissive wall and the photoelectrode. In addition, as discussed at Page 8, lines 7-9 of the subject application, the space formed between the light transmissive wall and the at least one semiconductor photoelectrode as claimed by Applicant facilitates the transport of the photoelectrolysis products, hydrogen and oxygen, away from the surfaces of the photoelectrodes because there is no electrolyte present within this space to impede such transport. Thus, the three-phase (gas, solid catalyst and liquid electrolyte) area is optimized to increase the solar energy efficiency. Applicant respectfully urges that the prior art relied upon by the Examiner for rejection of the subject application neither teaches nor suggests the invention claimed by Applicant.

Claim 14 has been rejected under 35 U.S.C. 102(b) as being anticipated by Gordon, U.S. Patent 4,400,451 (hereinafter "the Gordon patent"). Applicant respectfully traverses this rejection. The Gordon patent teaches a liquid-junction photoelectrochemical semiconductor cell adapted for providing electricity, fuel, chemicals and/or chemical energy which utilize a photoactive true solid/solid solution semiconductor mixed metal oxide material bulk or film electrode (Abstract). As

discussed at Col. 4, lines 8-30 and as shown in Figs. 1 and 2 of the Gordon patent, the disclosed cell comprises a first electrode comprising a semiconducting layer 11 disposed on an electrically conducting substrate 12 and a second electrode comprising a semiconductive layer 13 having a conductivity type opposite that of the first electrode *disposed against an electrically conductive light transparent substrate 14* with a liquid electrolyte 15 disposed between and in intimate contact with the first and second electrodes. Given that there is no space between the electrodes and the light transmissive wall in which substantially no electrolyte is disposed as required by Applicant's claimed invention, Applicant respectfully urges that the Gordon patent does not anticipate the invention claimed by Applicant in the manner required by 35 U.S.C. 102(b).

Claims 15-21 and 23-25 have been rejected under 35 U.S.C. 103(a) as being unpatentable over the Gordon patent. Applicant respectfully traverses this rejection. Applicant's arguments with respect to the Gordon patent as set forth herein above in connection with the rejection of Claim 14 are equally applicable to this rejection and, thus, will not be repeated, other than to reiterate that the Gordon patent neither teaches nor suggests the disposition of at least one of the photoelectrodes of the claimed cell at a distance from a light transmitting wall of the cell enclosure,

thereby forming a space in which substantially no electrolyte is present, as required by Applicant's claimed invention.

Claim 15 of the subject application requires that both the semiconductor photoanode and semiconductor photocathode 25, 27 comprise a proton exchange membrane having one surface facing and in contact with the electrolytic solution and having the other surface facing the light transmissive enclosure, and having a semiconductor layer 24, 26 disposed on the light transmissive enclosure facing surface, as shown in Fig. 2 of the subject application. In contrast thereto, the Gordon patent teaches a cell having a solid electrolyte system comprising a combination of an ionomer or polymer solvated with a liquid electrolyte, e.g. the lithium sulfonated form of NAFION®. The electrolyte is cast directly onto the first electrode of the cell (Col. 10, lines 42-45). As described at Col. 4, lines 19-30, this solid electrolyte 25 is disposed between the first and second electrodes 22, 24 as shown in Fig. 2 of the Gordon patent. Thus, *in contrast to the invention claimed by Applicant in which the proton exchange membrane forms part of the photoanode and/or photocathode*, the proton exchange membrane of the Gordon patent *is the electrolyte* of the cell and not part of the anode or cathode. In addition, in the embodiments of the cells shown in Figs. 1 and 2 of the Gordon patent, there is a semiconductor layer 11, 13 and 21, 23 also disposed between the first and second electrodes and in contact with the solid

electrolyte 25. That is, *the semiconductor layers are disposed on the electrolyte facing surfaces of the electrodes and not on the light transmissive enclosure facing surfaces of the proton exchange membrane electrodes as required by Applicant's claimed invention.* Accordingly, Applicant respectfully urges that the Gordon patent does not teach or suggest a photoelectrochemical cell having photoelectrodes comprising proton exchange membranes and having semiconductor layers disposed on the surfaces of the proton exchange membrane electrodes facing toward the light transmissive enclosure and, thus, away from the electrolyte, as claimed by Applicant. Thus, Applicant respectfully urges that the Gordon patent does not render Applicant's claimed invention obvious in the manner required by 35 U.S.C. 103(a).

Claims 1-13, 22 and 26 have been indicated to lack an inventive step under PCT Article 33(3) as being obvious over the Gordon patent in view of Holzbock et al., U.S. Patent 6,409,893 B1 (hereinafter "the Holzbock et al. patent"). Applicant respectfully traverses this rejection. Applicant's arguments with respect to the Gordon patent as set forth herein above are equally applicable to this rejection and, thus, will not be repeated, other than to reiterate that the Gordon patent neither teaches nor suggests the disposition of at least one of the photoelectrodes of the claimed cell at a distance from a light transmitting wall of the cell enclosure, thereby forming a space in which substantially no electrolyte is present as required by

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Applicant's claimed invention, nor does the Gordon patent teach or suggest a photoelectrochemical cell having photoelectrodes comprising proton exchange membranes and having semiconductor layers disposed on the surfaces of the proton exchange membrane electrodes facing toward the light transmissive enclosure and, thus, away from the electrolyte, as claimed by Applicant.

The Holzbock et al. patent is relied upon by the Examiner as teaching disposition of a photo electro-catalyst on the light transmissive wall facing side of a proton exchange membrane semiconductor photoelectrode of a photoelectrochemical cell as claimed by Applicant. The Holzbock et al. patent teaches a photoelectrochemical cell comprising a work electrode, a counter electrode having a catalytically active surface comprising an electrically conductive polymer, such as polyaniline or polypyrrole, and an electrolyte disposed between the two electrodes. The Examiner argues that it would have been obvious to have incorporated the coating of the side of the electrode facing the electrolyte with a catalytically active polymer layer as taught by the Holzbock et al. patent to the electrodes of the Gordon patent in order to achieve long term stability and catalytic activity as taught by the Holzbock et al. patent. The Examiner further argues that because the combination of the Gordon patent and the Holzbock et al. patent teaches that the catalytic layer is disposed on the side of the electrode facing the electrolyte, it would be inherent that

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the catalytic layer is disposed on the light transmissive wall facing surface of the proton exchange membrane as claimed. Applicant respectfully urges that, if the electrolyte disposed between the electrodes of the cell of the invention claimed by Applicant were a proton exchange membrane, the Examiner's assertion might be correct. However, contrary to the Examiner's assertion, the electrolyte of the cell of Applicant's claimed invention is an electrolytic solution *and not a proton exchange membrane*. Rather, *it is the electrodes of the cell of the invention claimed by Applicant which are made of proton exchange membranes, and the catalytically active material is disposed on the surfaces of the proton exchange membrane electrodes facing the light transmissive walls of the light transmissive enclosure*. Accordingly, because neither the Gordon patent nor the Holzbock et al. patent teach or suggest a photoelectrochemical cell, disposed within a light transmissive enclosure, comprising at least one photoelectrode comprising a proton exchange membrane and having a semiconductor catalytic layer disposed on a surface of the proton exchange membrane facing the light transmissive wall of the enclosure as in the invention claimed by Applicant, Applicant respectfully urges that the Gordon patent and the Holzbock et al. patent, alone or in combination, do not render Applicant's claimed invention obvious in the manner required by 35 U.S.C. 103(a).

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Claims 13 and 26 have been rejected under 35 U.S.C. 103(a) as being unpatentable over the Gordon patent in view of the Holzbock et al. patent, and further in view of Fleischer et al., U.S. Patent Application 2002/0127474 A1 (hereinafter “the Fleischer et al. application”). Applicant respectfully traverses this rejection. Applicant’s arguments with respect to both the Gordon patent and the Holzbock et al. patent are equally applicable to this rejection and, thus, will not be repeated here. The Holzbock et al. patent is relied upon by the Examiner as teaching that photoelectrochemical cells can be connected into a module by a circuit element, based upon which the Examiner argues that it would have been obvious to one of ordinary skill in the art to have connected the cells of the Gordon patent using a connecting circuit element to form a module as taught by the Holzbock et al. patent since the Fleischer et al. application teaches that multi-cell packs might be needed for applications that require larger voltages. The Examiner further argues that one of ordinary skill in the art would have found the use of metal connectors as claimed by Applicant obvious since metal connectors are conventionally used to establish physical and electrical connections between two bodies. Notwithstanding, Applicant respectfully urges that because neither the Gordon patent nor the Holzbock et al. patent teach or suggest a photoelectrochemical cell, disposed within a light transmissive enclosure, comprising at least one photoelectrode comprising a proton

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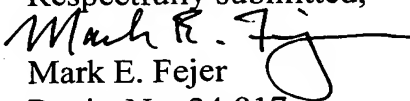
exchange membrane and having a semiconductor catalytic layer disposed on a surface of the proton exchange membrane facing the light transmissive wall of the enclosure as in the invention claimed by Applicant, application of the teachings of the Fleischer et al. application to the combination of the teachings of the Gordon and Holzbock et al. patents would not result in the invention claimed by Applicant. Accordingly, Applicant respectfully urges that the Gordon patent, the Holzbock et al. patent and the Fleischer et al. application, alone or in combination, do not render Applicant's claimed invention obvious in the manner required by 35 U.S.C. 103(a).

Conclusion

Applicant intends to be fully responsive to the outstanding Office Action. If the Examiner detects any issue which the Examiner believes Applicant has not addressed in this response, Applicant urges the Examiner to contact the undersigned.

Applicant sincerely believes that this patent application is now in condition for allowance and, thus, respectfully requests early allowance.

Respectfully submitted,


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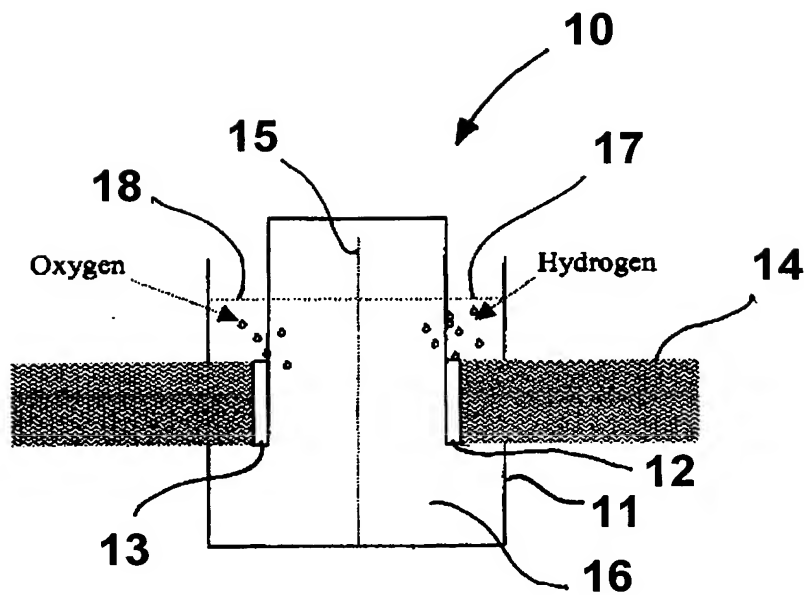


Fig. 1

Prior Art

Label added

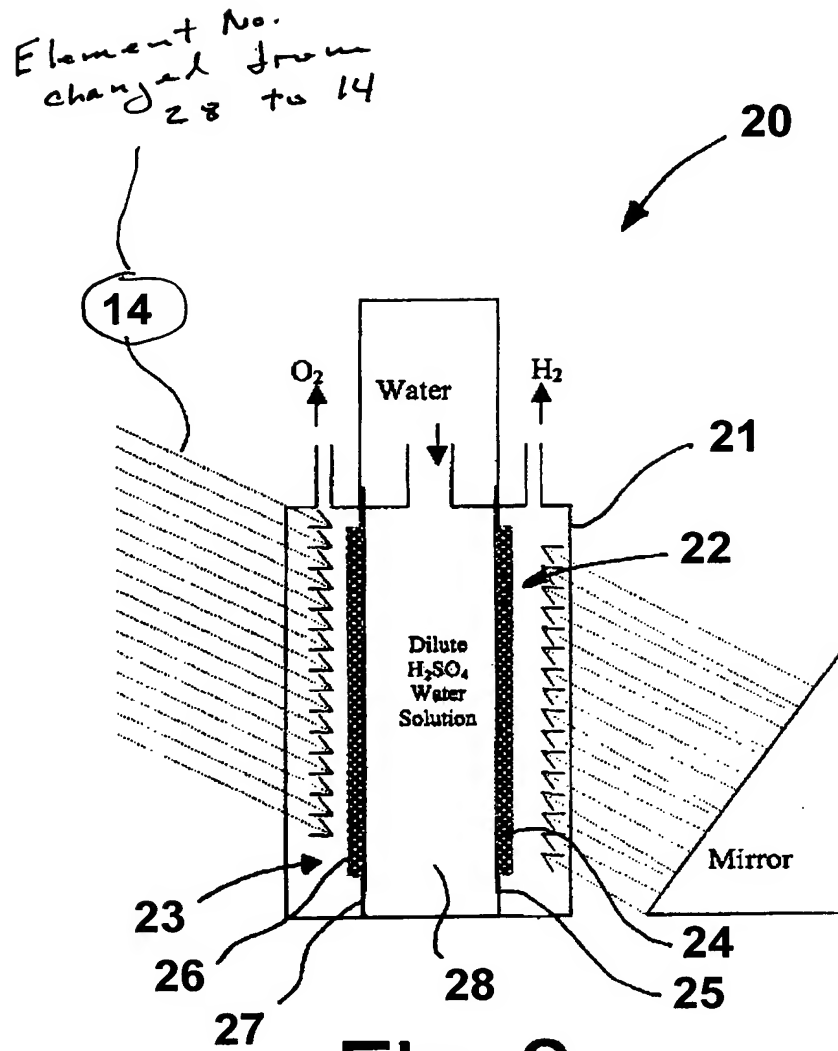


Fig. 2

Element No.
changed from
28 to 14

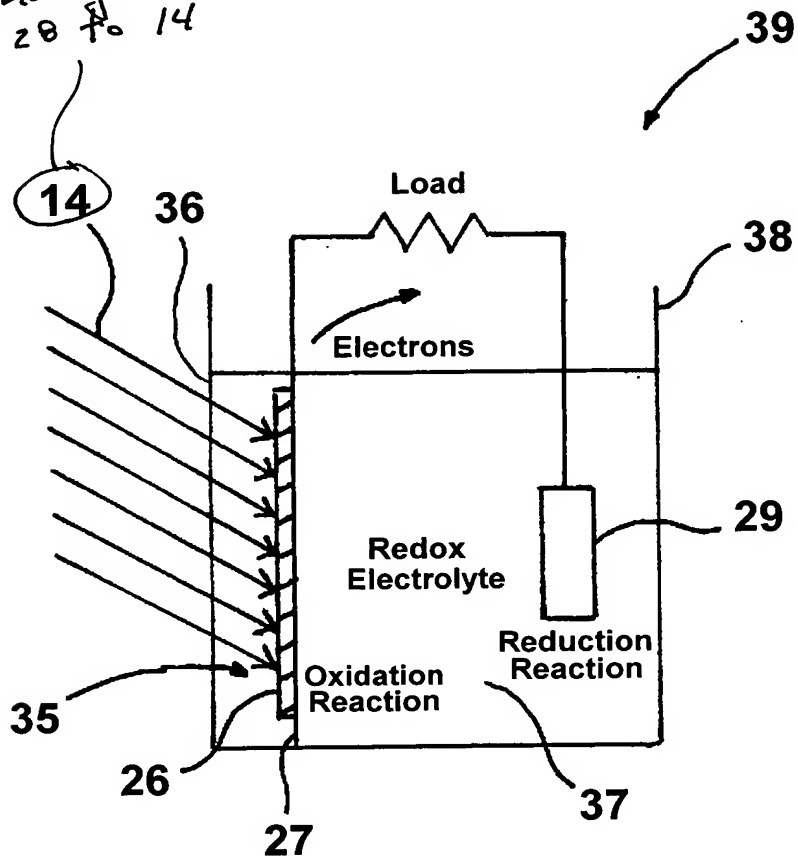


Fig. 3